CNTT-E-114

BASIC ELECTRICITY AND ELECTRONICS

STUDENT HANDOUT NO. 207

SUMMARIES PROGRESS CHECKS FOR MODULES

22 LESSON 4

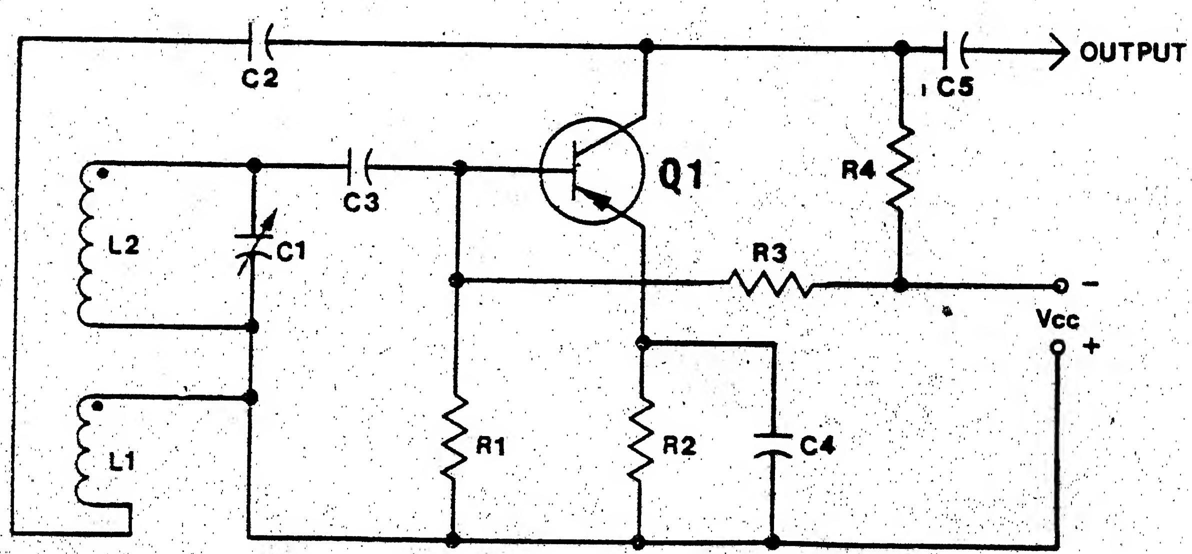
JUNE 1984

SUMMARY
LESSON IV

Oscillator Operation

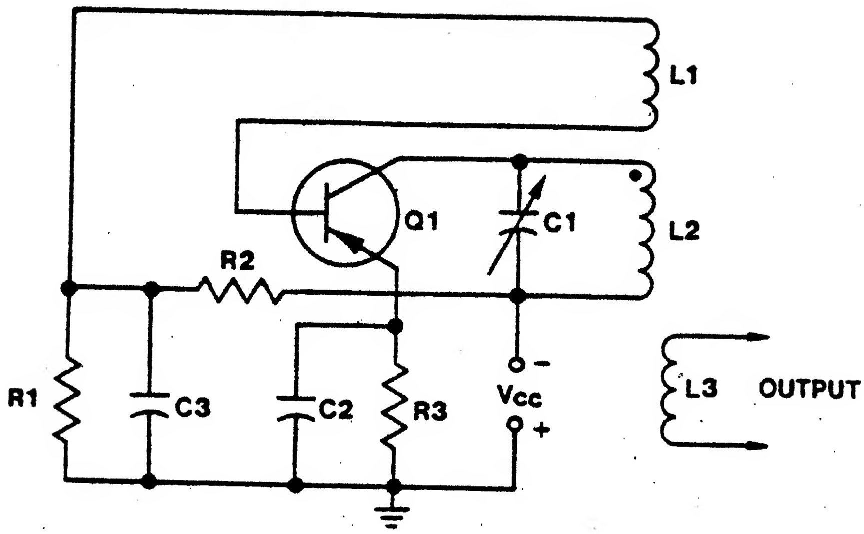
A feedback path and an amplifier must be added to a tank circuit in order to sustain oscillations. The amplifier will typically be a common-emitter amplifier which has a 180° phase shift. In order to replenish the losses in the tank circuit at the correct phase, there must also be 180° of phase shift in the feedback path. This type of feedback is called positive or regenerative.

An Armstrong oscillator uses a common-emitter amplifier and inductive feedback.



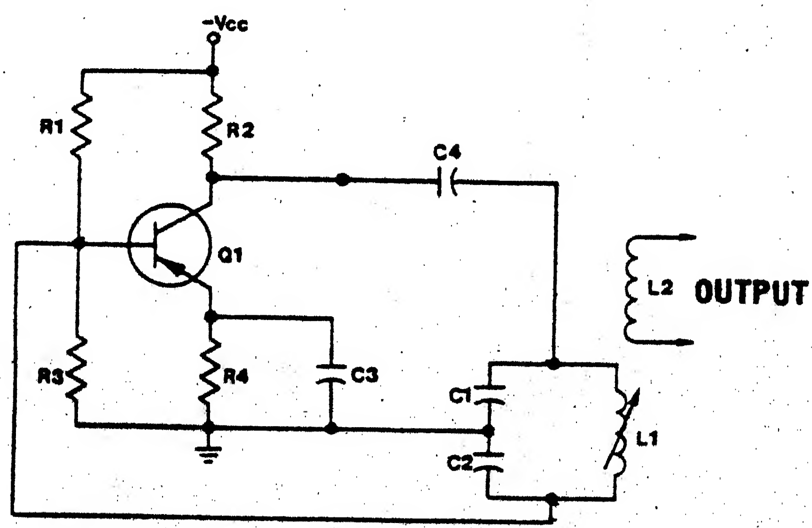
Sine wave oscillations are established in the tank circuit consisting of L2 and C1. These oscillations are fed through coupling capacitor C3 to the base of transistor amplifier Q1. The transistor amplifies the sine wave and part of the energy is coupled through C5 to the output. The remainder of the energy is fed back through C2 to "tickler" coil L1. L1 puts energy back into the tank through mutual induction with L2. Oscillations are thus sutained.

A variation of the Armstrong oscillator is shown on the next page:



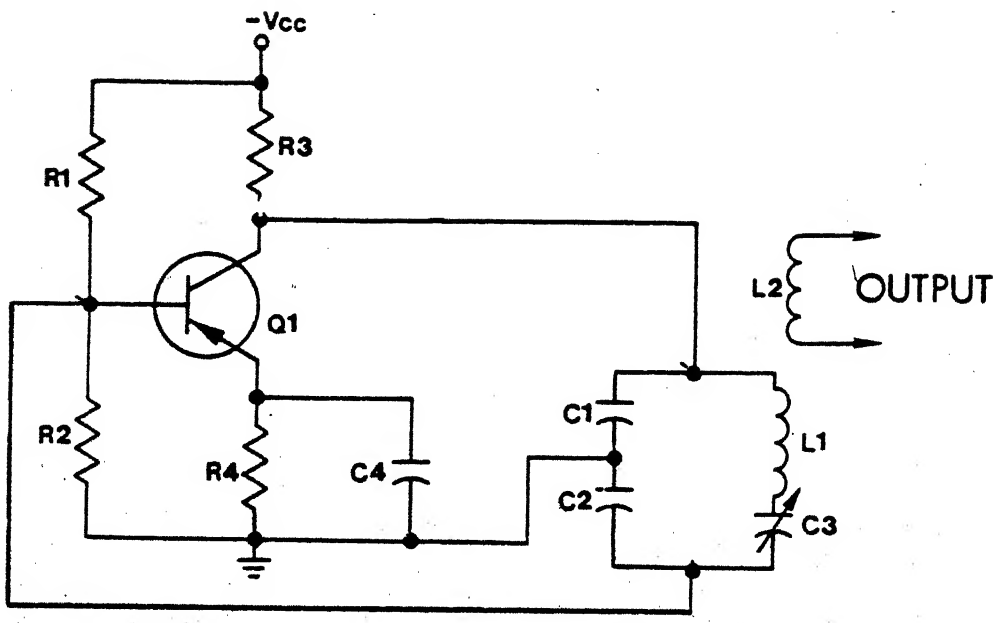
Energy from the tank circuit (L2 and C1) is coupled to the output via L3 and to the feedback path via L1. Transistor Q1 amplifies the energy from L1 and injects the energy right back into the tank.

A Colpitts oscillator utilizes two capacitors and a variable inductor in the tank.



Part of the sinewave energy is taken from capacitor C2, amplified, and fed back to capacitor C1. Inductor L1 is used to vary the frequency of oscillation. The oscillator output is taken from coil L2 which is wound on the same core with L1.

A variation of the Colpitts oscillator is the Clapp oscillator:



Here the tank consists of C1, C2, C3, and L1, and the frequency of oscillation can be changed by varying C3.

When measuring voltages in an oscillator circuit with a meter rather than an oscilloscope, an electronic voltmeter (EVM, DMM or VTVM) must be used to prevent circuit loading (frequency change and loss of amplitude).

AT THIS POINT, YOU MAY PROCEED TO PART I OF THE JOB PROGRAM. IF YOU FEEL THAT YOU HAVE FAILED TO UNDERSTAND ALL, OR MOST OF THIS LESSON, SELECT AND USE ANOTHER WRITTEN MEDIUM OF INSTRUCTION, AUDIO/VISUAL MATERIALS (IF APPLICABLE), OR CONSULTATION WITH YOUR LEARNING CENTER INSTRUCTOR, UNTIL YOU UNDERSTAND THE MATERIAL IN THIS LESSON.

AUDIO-VISUAL RESPONSE SHEET
LESSON IV

Basic Oscillator Operation

ANSWER ALL QUESTIONS IN STATIC/MOTION PROGRAM TWENTY TWO-IV-1 ON THIS RESPONSE SHEET.

1. A B C D CIRCLE ONE

2. A B C D CIRCLE ONE

3. A B C D CIRCLE ONE

4. Component(s): ______________________ .

5. ____________________________________ .

6. Component(s): ______________________ .

JOB PROGRAM
FOR
LESSON IV

PART I

Oscillator Operation

INTRODUCTION

The operation of an oscillator circuit will be investigated in this section of the job program. You will build an actual oscillator circuit and make appropriate measurements to verify that the circuit operates according to theory.

EQUIPMENT AND MATERIALS

1. Device 6F16
2. Template "C" Basic Oscillator
3. Oscilloscope (6B28)

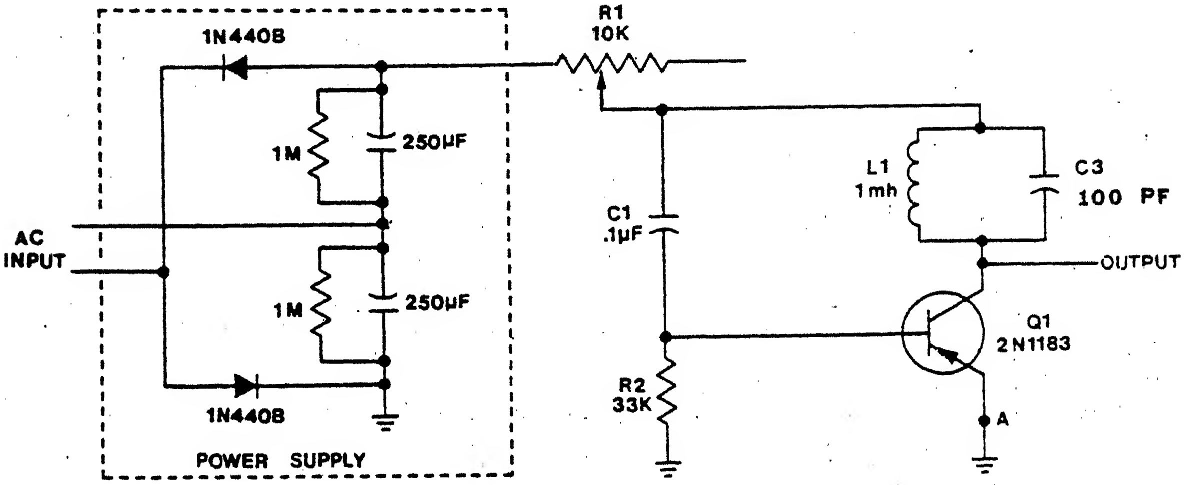
PROCEDURE

1. Using all applicable safety precautions, energize the oscilloscope.

    a. Obtain a line trace.
    b. Set the VOLTS/DIV control to 10 volts/div.
    c. Set the TIME/DIV control to 1 microsecond/div.
    d. Connect a 1X probe to the Channel 1 INPUT jack.

2. Set up the 6F16 transistor trainer as follows:

a. Using template C, Basic Oscillator, assemble the circuit illustrated below.



b. Looking at the potentiometer from the knob side rotate the potentiometer, R1, to the fully conter-clockwise position.

c. Connect the 1X probe to the output of the oscillator. Connect the ground lead to point A on the oscillator.

d. Connect the power cord to the 6F16 device, plug it in, and place the power switch to the "ON" position.

e. Rotate the potentiometer R1 clockwise to obtain the least distorted sine wave on the oscilloscope screen. (NOTE: If the potentiometer is turned too far, oscillations will stop.)

3. a. Calculate the frequency of the waveform displayed on the oscilloscope screen.

ANS. ________________________________.

b. Identify the components of this oscillator which are the:

Tank ____________
Amplifier ____________
Feedback ____________

4. The feedback path for this oscillator is provided through Capacitor C1. Remove C1 from the circuit and observe what happens to the waveform displayed on the oscilloscope screen. (Use the pry-up tool). Notice that the waveform dies out too quickly to observe the damping effect. (Replace capacitor C1 into the circuit before continuing.)

5. Replace the 100 pf tank capacitor, C3, with a 500 pf capacitor. Re-adjust potentiometer R1 to obtain the best sine wave on the oscilloscope screen. Calculate the frequency of the waveform now displayed on the oscilloscope screen.

ANS. ______________________________

a. You increased the value of the tank capacitor, C3. Did the frequency of oscillations increase or decrease? Is this consistent with theory?

ANS. ______________________________

(Ensure that tank capacitor, C3, is replaced with the 100 pf capacitor before continuing).

6. Replace the 1 mh tank inductor, L1, with a 2.5 mh inductor. Again re-adjust potentiometer R1 to obtain the best sine wave on the oscilloscope screen. Calculate the frequency of the waveform displayed.

ANS. ______________________________

a. You increased the value of the tank inductance. Did the frequency of oscillations increase or decrease? Is this consistent with theory?

ANS. ______________________________

7. Return the 1 mh tank inductor to the circuit.

8. De-energize the 6F16 device. Use the pry-up tool to remove the components, and replace them in their proper place in the component half of the 6F16 device. Return all equipment to its proper stowage.

AT THIS POINT, YOU MAY PROCEED TO PART II OF THE JOB PROGRAM. IF YOU FEEL THAT YOU HAVE FAILED TO UNDERSTAND ALL, OR MOST OF THIS LESSON, SELECT AND USE ANOTHER WRITTEN MEDIUM OF INSTRUCTION, AUDIO/VISUAL MATERIALS (IF APPLICABLE), OR CONSULTATION WITH YOUR LEARNING CENTER INSTRUCTOR, UNTIL YOU UNDERSTAND THE MATERIAL IN THIS LESSON.

JOB PROGRAM
FOR
LESSON IV

PART II

Loading Effect of Meters

EQUIPMENT AND MATERIALS

1. VOM
2. EVM (Electronic Voltmeter)
3. Oscilloscope (6B28)
4. Device 6F16
5. Template "C"
6. 1X Probe

PROCEDURE

1. a. Using Template "C" assemble the circuit illustrated on page 207-7

   b. Connect the oscilloscope to the output of the oscillator. (Ensure probe is grounded).

   c. Adjust the oscillator for maximum undistorted output. ("10K pot").

   d. Use the oscilloscope to measure the RMS value of the output sine wave (RMS is 0.707 times peak).

   ANS. ______________________ VAC .

2. Use the VOM to measure the output of the oscillator.

   a. Black lead at ground, red lead in oscillator output jack.

   b. Start with the 50 volt scale and record the AC volts in the space provided for each setting of the meter.

   50 V Scale ______________ VAC .

   10 V Scale ______________ VAC .

3. With the VOM on the 10 V scale adjust the oscillator for maximum output. Notice how much better the meter loads the circuit.

4. When you connect the VOM to the output of the oscillator what happened to the frequency of the oscillations?

The frequency ______________________________________.

5. Measure the AC voltage at the output of the oscillator with the EVM. See Notes below.

a. ANS. ______________________ VAC.

How does this value compare with the value measured by the oscilloscope?

b. ____.

c. Did the EVM change the frequency appreciably?

NOTE: It is suggested that this measurement be made with the meter set for 30 VAC. The 30 VAC scale is read on the black 3.0 volt graduations.
Remember to zero the meter with the ZERO ADJUST before taking the measurement.

De-energize 6F16. Use pry-up tool to remove components from 6F16 device, and replace them in component half of 6F16 device.
Return all equipment to its proper stowage.

AT THIS POINT, YOU MAY PROCEED TO PART III OF THE JOB PROGRAM. IF YOU FEEL THAT YOU HAVE FAILED TO UNDERSTAND ALL, OR MOST OF THIS LESSON, SELECT AND USE ANOTHER WRITTEN MEDIUM OF INSTRUCTION, AUDIO/VISUAL MATERIALS (IF APPLICABLE), OR CONSULTATION WITH YOUR LEARNING CENTER INSTRUCTOR UNTIL YOU UNDERSTAND THE MATERIAL IN THIS LESSON.

JOB PROGRAM
FOR
LESSON IV

PART III

Colpitts/Armstrong Oscillators

This job program will demonstrate the principles of operation of two basic oscillator circuits -

1. Colpitts Oscillator
2. Armstrong Oscillator

Beware of all open and base connections on the NIDA 203 Oscillator. Remember, even low voltages can KILL!

REFERENCE(S)

1. Technical Manual for NIDA 203 Audio Oscillator

EQUIPMENT AND MATERIALS

1. NIDA 203 Audio Oscillator
   PC 203-2 Printed Circuit Card
   PC 203-5 Printed Circuit Card

2. Oscilloscope (6B28)
3. 1X Probe (2)
4. NIDA 203 Audio Oscillator Instruction Manual

PROCEDURE

1. Energize and set up the oscilloscope for dual trace operation.

2. Connect a 1X Probe to Channel 1 of the oscilloscope. Connect the other 1X Probe to Channel 2 of the oscilloscope.

3. Remove the top cover of the oscillator.

   NOTE: Perform the following procedures for the Colpitts Oscillator, PC-203-2, then, after step 13, come back to Step 4 and repeat the procedures using the Armstrong Oscillator, PC-203-5.

4. Insert PC Board 203-2 (203-5) into the NIDA 203 Oscillator chassis.

5. Plug in and energize the Oscillator.

6. Rotate the amplitude control on the front panel of the Oscillator fully "clockwise". Disregard the multiplier and frequency controls, as these controls have no effect when using the PC 203-2 and PC 203-5 boards.

Refer to pages 4-6, 4-9, and 5-9 in the NIDA 203 Instruction Manual for location of test points during this job program.

7. Measure and record the PERIOD of the output signal.

PC 203-2 ______________________________ microseconds.

PC 203-5 ______________________________ microseconds.

8. What is the output FREQUENCY?

PC 203-2 ______________________________ KHz.

PC 203-5 ______________________________ KHz.

9. What type of amplifier is used in this circuit? (common base, common collector, common emitter).

PC 203-2 ______________________________

PC 203-5 ______________________________

10. Measure the phase relationship between the output signal at PIN 7 and the feedback signal to the base of Q1.

PC 203-2:
a. In phase
b. 90 degrees out of phase
c. 180 degrees out of phase
d. 270 degrees out of phase

PC 203-5:
a. In phase
b. 90 degrees out of phase
c. 180 degrees out of phase
d. 270 degrees out of phase

11. What components of the circuit determine the oscillator frequency?

PC 203-2: ______________, ______________, ________________.

PC 203-5: ______________, ______________.

12. De-energize the Oscillator, and remove the PC card.

13. Go back to Step 4 and repeat the procedures using PC Board 203-5.

AT THIS POINT, YOU MAY PROCEED TO PART IV OF THE PROGRAM. IF YOU FEEL THAT YOU HAVE FAILED TO UNDERSTAND ALL, OR MOST, OF THIS LESSON, SELECT AND USE ANOTHER WRITTEN MEDIUM OF INSTRUCTION, AUDIO/VISUAL MATERIALS (IF APPLICABLE), OR CONSULTATION WITH YOUR LEARNING CENTER INSTRUCTOR, UNTIL YOU UNDERSTAND THE MATERIAL IN THIS LESSON.

JOB PROGRAM
FOR
LESSON IV
PART 4

Troubleshooting Oscillators

INTRODUCTION

This job program is designed to provide the technician with a better understanding of troubleshooting oscillators using the six-step troubleshooting method and give the technician some experience with transistor circuit biasing.

EQUIPMENT AND MATERIALS

1. NIDA 203 Audio Oscillator
   PC203-2-1 Trouble Card
   PC203-5-4 Trouble Card
2. Oscilloscope
3. Multimeter and meter leads
4. 1X Probe
5. BNC to BNC cable (1)

REFERENCE MATERIAL

1. NIDA 203 Audio Oscillator Instruction Manual.

PROCEDURE:

1. Energize the oscilloscope.

2. Using a BNC-BNC cable, connect the NIDA 203 Oscillator to the oscilloscope.

3. Remove the top cover of the oscillator.

4. Insert Trouble Card PC203-2-1 into the NIDA 203 Oscillator chassis.

5. Plug in and energize the oscillator.

6. Rotate the AMPLITUDE control on the front panel of the oscillator fully "clockwise". Disregard the MULTIPLIER and FREQUENCY controls. These controls have no effect when using the PC203-2 and PC203-5 cards.

NOTE: Refer to page 4-6 in the NIDA 203 Instructional Manual during this part of the job program.

7. Step 1 of the Six-Step Troubleshooting Procedure is recognizing the symptom or symptoms by observing the presentation or noting the meter readings during operation or preoperational checkout.

On a major equipment or system this step could list several symptoms. With the less complex NIDA 203, however, this step will not require too complex an answer considering the only observation that can be made is of the output.

At this time observe the oscilloscope for an output from the NIDA 203. Since there is no output, and that is all that can be done for symptom recognition with this piece of equipment, step 1 will be:

Step 1. No Output.

In Step 2, symptom elaboration, we can go a little further. On the NIDA 203, we have a power switch which lights when energized. We will use this indication to state that primary power is available, and that the equipment is energized.

Step 2. AC applied, Equipment energized.

In Step 3, we list the probable faulty units or functions, by using a

functional block diagram and the information gained in Steps 1 and 2. Referring to the functional block diagram provided, determine which functions could cause our symptom.

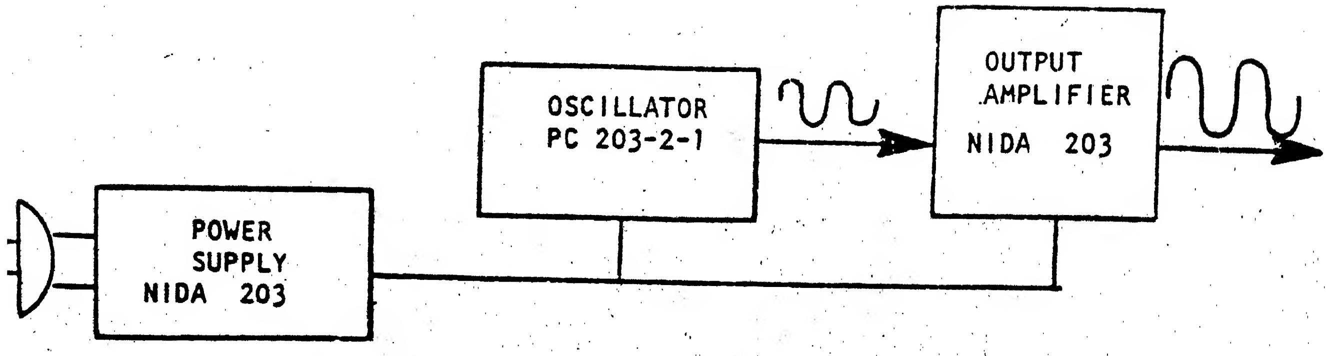


Figure 1

Step 3. Power Supply, Oscillator, Output Amplifier.

We list the power supply because at this time we only know that the "POWER" light comes on. There could be no output from the power supply unit.

In Step 4, we localize the faulty unit/function. Disconnect the BNC-BNC cable from the oscilloscope and the output of NIDA 203. Connect the 1X probe to the oscilloscope. Using the 1X probe, observe the output of the oscillator as shown below.

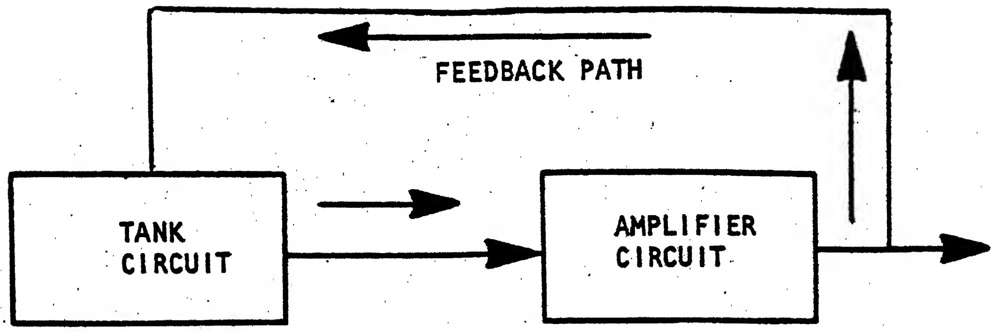
Point of Check	Reference Reading	Actual Reading
PC 203-2 Pin 7		No Signal

If you have an output, notify your Learning Center Instructor. Next check to see if the power supply is providing the proper voltage. Switch the oscilloscope to DC before doing this check.

Point of Check	Reference Reading	Actual Reading
PC 203-2 Pin 6	+ 22 VDC	+ 22 VDC

By these checks we have determined the faulty function is the oscillator.

In troubleshooting oscillators you should understand that if either circuit, tank or amplifier, fails to operate there will be no output. (See Figure 2). The only other problem you might encounter is a bad feedback circuit (usually consisting of one component).



8. To localize the faulty circuit, we perform Step 5. We will start by reading the voltages associated with the amplifier circuit. Remember when you studied classes of bias in a previous module? Q1 is a Class "A" amplifier, which means in a properly operating circuit there will be some current flow through the transistor at all times. (See Figure 3B).

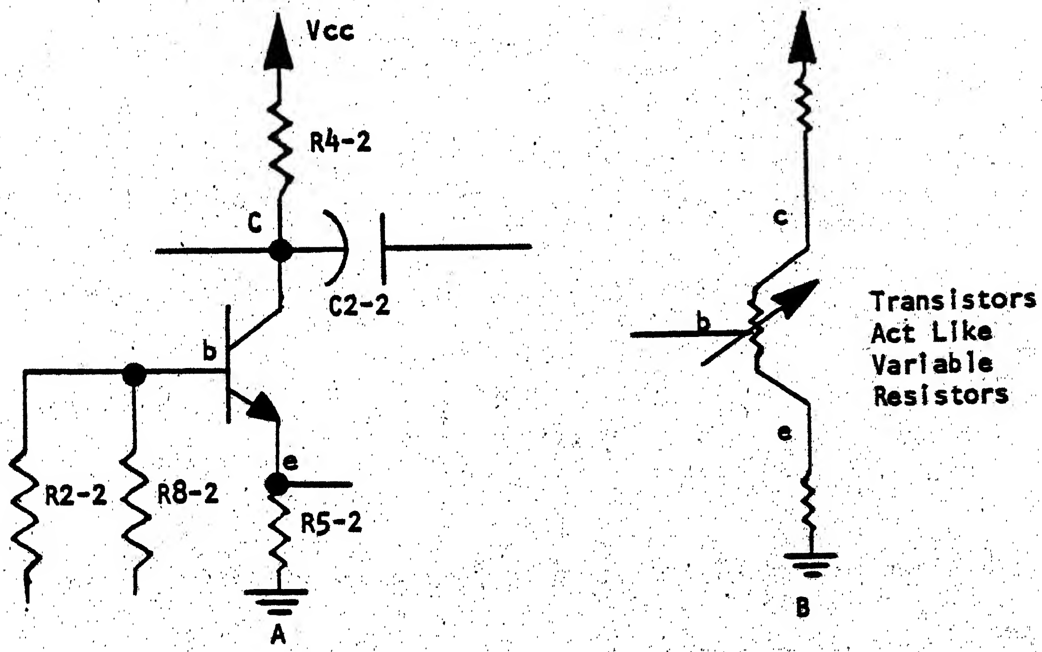


Figure 3

Referring to Figure 3A, and the NIDA 203 Tech Manual page 4-6 and Table 3-2 on page 3-2 use the oscilloscope make the checks listed for Q1-2, and compare your readings to those listed in the table.

If your readings do not match these, notify your Learning Center Instructor.

From your readings you can see that the amplifier circuit is operating properly, which means the tank circuit is faulty.

9. In Step 6 we will determine which component is at fault, and we will analyze the failure. When troubleshooting tank circuits, the preferred method is by resistance checks. The oscilloscope will load the circuit if readings are taken directly on the tank, and DC voltage potentials in the tank are low or zero in most cases. De-energize the NIDA 203 Oscillator, and measure the DC resistance of the tank circuit.

Point of Check	Reference Reading	Actual Reading
L1-2	5Ω - 700Ω	1.5 KΩ or more

In a good circuit the reading would be low, because the coil has a low DC resistance and the capacitors appear as an open circuit. In this circuit we see that the coil is bad.

Faulty Circuit Component L1-2 Open

In analyzing this problem, we can eliminate excessive current as a cause of failure in this case. If we had excessive current, R6-2, R8-2, and possibly R2-2 would have to have become low in resistance first. The problem could have been caused by vibration, heat, deterioration of L1-2, or worst of all, by the technician. With the coil open, no oscillations were present, therefore no output. As you saw, the transistor functioned properly.

10. In this next problem, the "Point of Check" and the "Reference Reading" will be provided, but the actual reading is up to you. Insert trouble card PC 203-5-4- into the NIDA 203 Oscillator chassis and energize the oscillator.

11. Refer to page 4-9 in the NIDA 203 Manual for this part of the job program.

12. Again in Step 1 you have to use the same observations for symptom recognition because of the basic equipment you are working with.

Step 1 ____________________.

13. Now in Step 2, we are elaborating on what we observed in Step 1. Work with the few front panel indicators you have and list the indications.

Step 2. ____________________.

14. In Step 3, you will use the functional block program provided below, determine which functions could be at fault, and list them below.

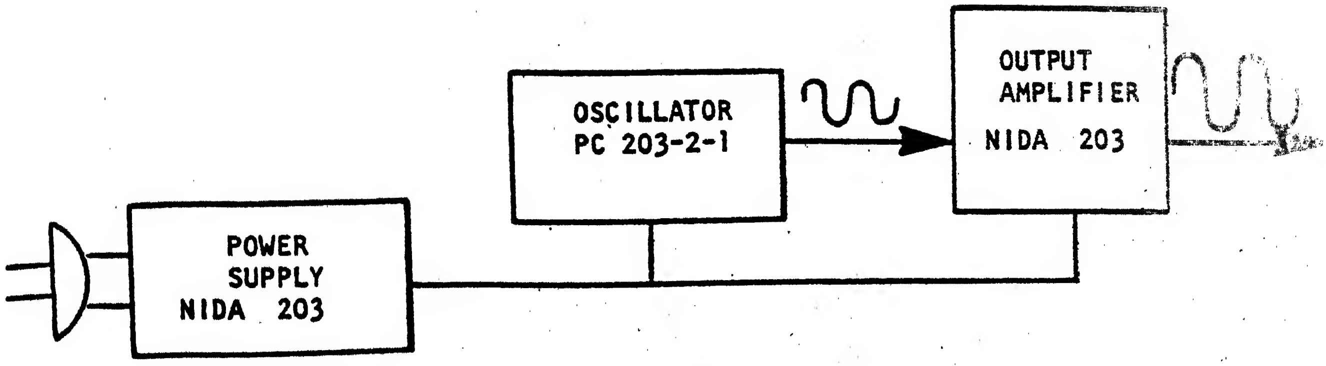


Figure 4

Step 3. ______________________________

15. To accomplish Step 4, which is localizing the faulty function, you will use test equipment to isolate the malfunction to one function. Refer to Figure 4, and to page 4-9 of the NIDA Manual.

Point of Check	Reference Reading	Actual Reading
PC 203-5 Pin 7	.2 vp-p	______
PC 203-5 Pin 6	+22 VDC	______
	Faulty Function	______

16. Now in Step 5, we are working within the faulty function to determine the faulty circuit. Refer to NIDA 203 Tech Manual page 3-3, Table 3-6 for reference readings, and compare your readings. List the faulty function.

Faulty Function ______

In this oscillator, as in the last, the transistor is supposed to be biased for Class "A" operation. From your readings, you should have determined the transistor is cut-off (high resistance - no current flow.) Shown in Figure 5 are <u>some</u> of the things that could cause the transistor to be cut-off. Illustrated are, (a) an open transistor, (b) an open biasing resistor, and (c) an open emitter resistor.

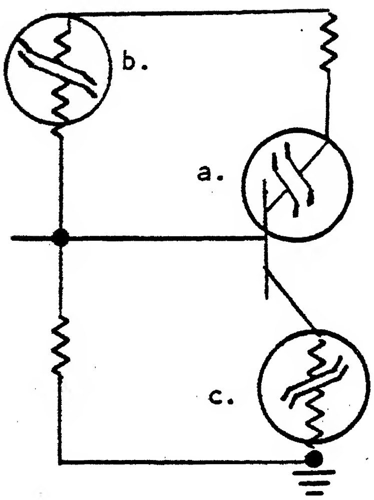


Figure 5

These components can be checked-out by measuring circuit voltages, and resistances and comparing the readings with normal circuit potentials, which is Step 6.

17. Step 6 is the failure analysis step. You are working towards discovery of the faulty component, and trying to determine the most logical cause of failure.

Point of Check	Reference Reading	Actual Reading
R1-5/R2-5 Junction	+12 to +16 VDC	

There is little or no current through the voltage divider consisting of R1, R2, and R4, as you have seen from your voltage readings. Use resistance checks to confirm the problem.

Faulty Circuit Component ____________________

Now explain why the faulty component would give you the symptoms you had in Steps 1 & 2.

18. You now have had the opportunity to apply the Six-Step Troubleshooting Method to two problems, one in the tank circuit, and one in the amplifier. In each case, there was no output from the oscillator. The procedure used here for troubleshooting transistors is applicable not only to school problems, but to "real life" problems as well. A thorough understanding of these procedures is beneficial in almost every troubleshooting situation.

19. De-energize and unplug the NIDA 203, remove the PC Board, and return all equipment to the proper location.

AT THIS POINT, YOU MAY TAKE THE LESSON PROGRESS CHECK. IF YOU ANSWER ALL SELF-TEST ITEMS CORRECTLY, PROCEED TO THE NEXT LESSON. IF YOU FEEL THAT YOU HAVE FAILED TO UNDERSTAND ALL, OR MOST, OF THE LESSON, SELECT AND USE ANOTHER WRITTEN MEDIUM OF INSTRUCTION, AUDIO/VISUAL MATERIALS (IF APPLICABLE), OR CONSULTATION WITH YOUR LEARNING CENTER INSTRUCTOR, UNTIL YOU CAN ANSWER ALL SELF-TEST ITEMS ON THE PROGRESS CHECK CORRECTLY.

PROGRESS CHECK
LESSON IV

Oscillator Operation

1. The purpose of L1 in Figure 1 is to

   a. establish the oscillator frequency.
   b. couple feedback energy to the resonant tank.
   c. couple energy out of the resonant tank.
   d. provide a DC path to ground.

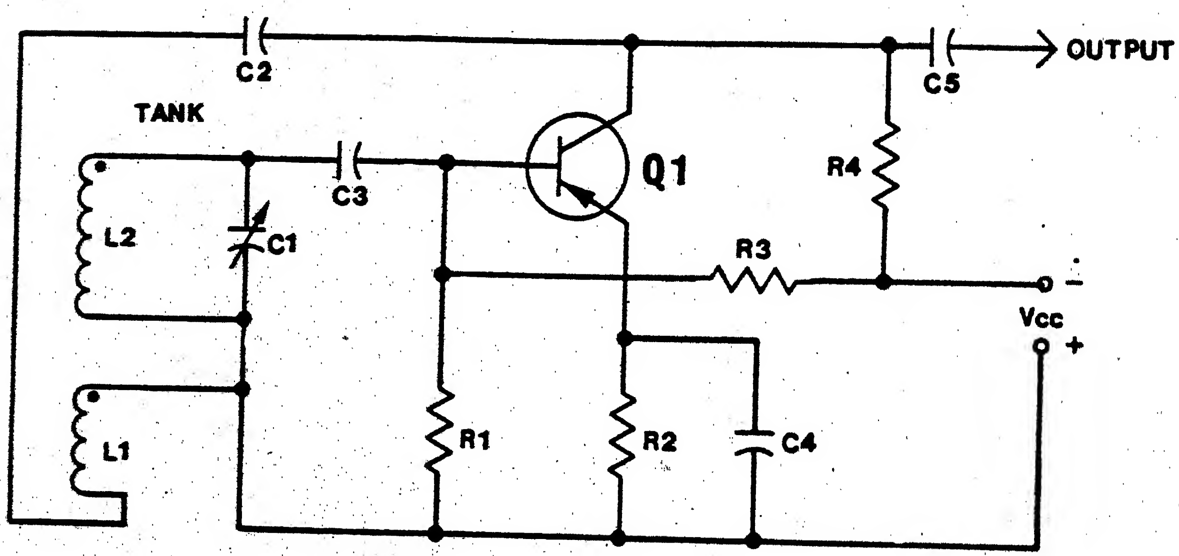


Figure 1

2. In figure 1, which component can be used to change the frequency of oscillation?

   a. C4
   b. L2
   c. Q1
   d. C1

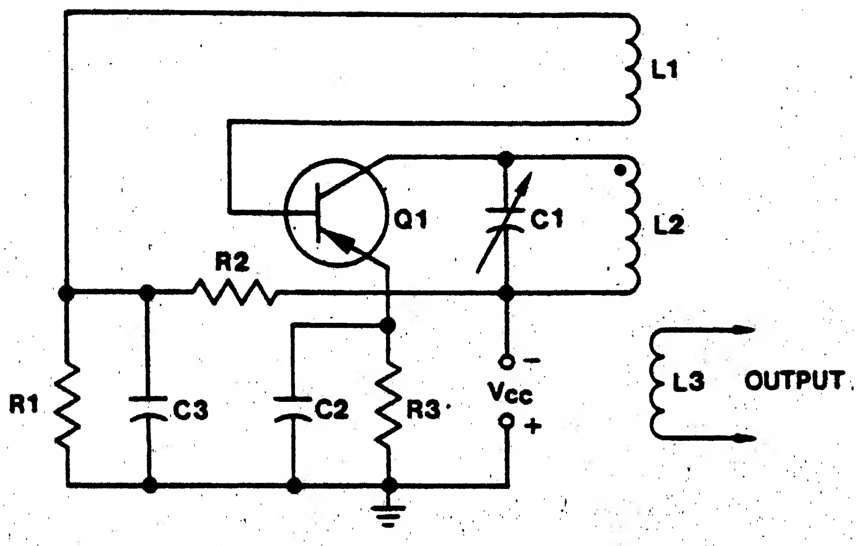


Figure 2

3. In figure 2, which inductor determines the frequency of oscillation?

   a. L1
   b. L2
   c. L3

4. In figure 2, the purpose of transistor Q1 is to

   a. feed amplified energy to the tank circuit.
   b. feed amplified energy to tickler coil L1.
   c. increase the energy of the DC supply voltage.
   d. establish the frequency of oscillation.

5. The amplifier and feedback path for the oscillator in figure 3 is from point

a. C, through Q1, through C2, to point A.
b. B, through C1, through Q1, through C2, to point A.
c. A, through C2, through Q1, to point C.
d. A, through C2, through Q1, through C1, to point B.

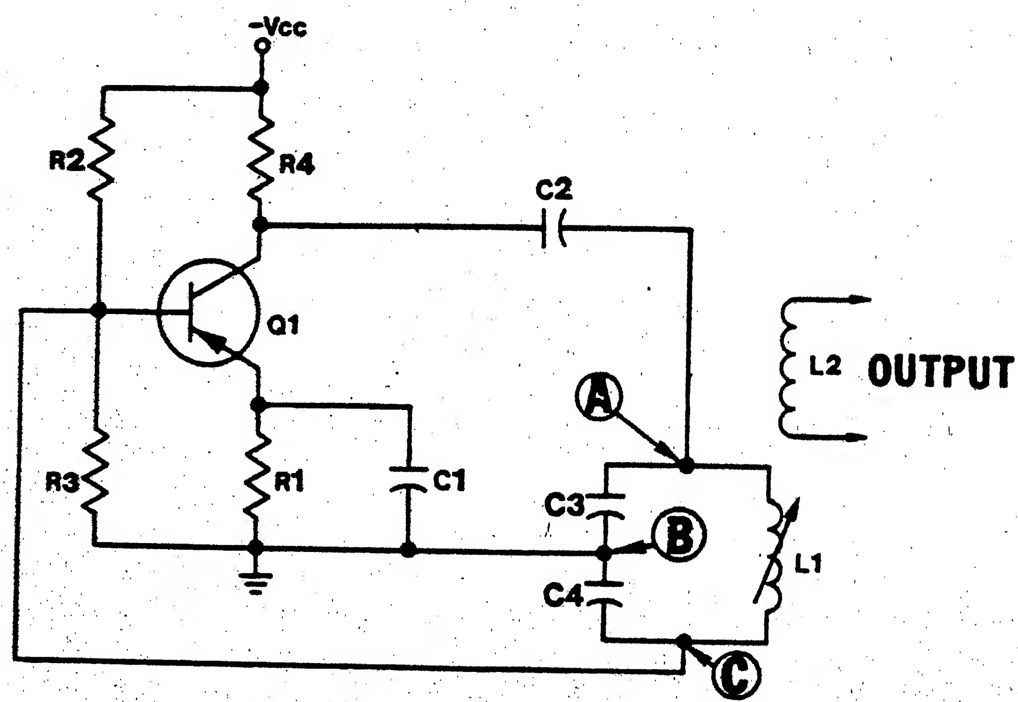


Figure 3

6. In figure 3, which components establish the frequency of oscillation?

a. C1, C2, C3, Q1
b. L1, L2, C1
c. R1, C1, C3, L1
d. C3, C4, L1

7. The purpose of capacitor C2 in Figure 4 is to

a. vary the frequency of oscillation.
b. adjust the bias on transistor Q1.
c. provide the correct amount of feedback energy.
d. adjust the amount of output energy.

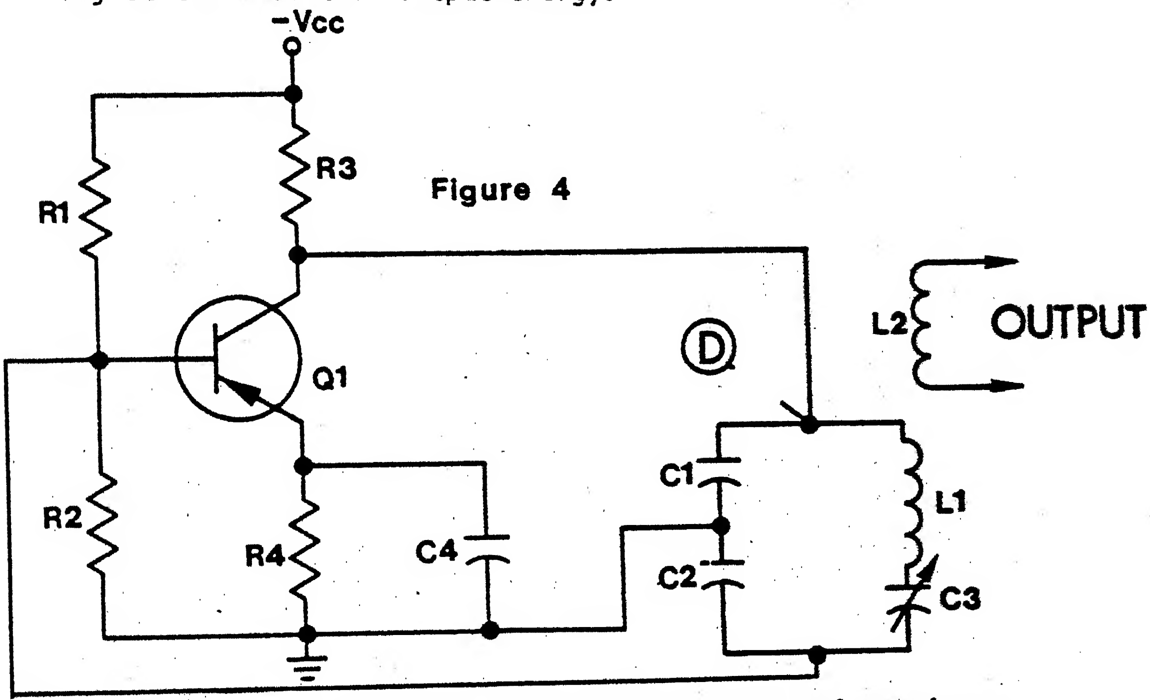


Figure 4

8. What test equipment should be used when measuring voltage in an oscillator circuit?

a. ______________________________

b. ______________________________

Why?

c. ______________________________

CHECK YOUR ANSWERS TO THIS PROGRESS CHECK WITH THE ANSWERS IN THE BACK OF YOUR STUDENT GUIDE. IF YOU FEEL THAT YOU HAVE FAILED TO UNDERSTAND ANY PART OF THIS LESSON YOU SHOULD CONSULT YOUR LEARNING CENTER INSTRUCTOR FOR ASSISTANCE AND REMEDIATION. IF YOU ANSWERED ALL QUESTIONS IN THE PROGRESS CHECK CORRECTLY, CONSULT YOUR LCI FOR ASSIGNMENT TO THE MODULE TEST.

ANSWER SHEET
FOR
LESSON IV
JOB PROGRAM

PART I — Oscillator Operation

3. a. 500KHz
   b. Tank-L1, C3; Amplifier-Q1; Feedback-C1

5. Frequency - 325KHz - 350KHz
   a. Frequency decreased, Yes

6. Frequency - 140KHz - 150KHz
   a. Frequency decreased, Yes

PART II — Loading Effects

1. d. 12V - 15VAC

2. b. 50V scale 10-15 VAC
   Note: Meter should be on Output function
   10V scale 2-5 VAC

4. Decreased

5. a. 11V - 14VAC
   b. Close
   c. No

PART III — Oscillators

7. PC 203-2 - 320µsec ± 10%
   PC 203-5 - 44µsec ± 10%

8. PC 203-2 - 3.1 KHz ± 10%
   PC 203-5 - 23 KHz ± 10%

9. PC 203-2 - common emitter amplifier
   PC 203-5 - common emitter amplifier

10. PC 203-2 - 180° out of phase
    PC 203-5 - 180° out of phase

11. PC 203-2 - C3-2, C4-2, L1-2
    PC 203-5 - C3-5, T1-5

ANSWER SHEET
FOR
LESSON IV
JOB PROGRAM

Troubleshooting Oscillators

12. No output

13. Power Available (Applied)
    Equipment Energized

14. Power Supply ("Power" light on doesn't eliminate power supply)
    Oscillator
    Output Amplifier

15. No signal
    +22 VDC
    Oscillator

16. +22 VDC
    0 to +2 VDC
    0 V
    Amplifier

17. 0 to +3 VDC

Point of Check	Reference Reading	Actual Reading
Resistance of R1-5	10KΩ	

R1-5 is open
R1-5 open prevented current through the voltage divider network. Q1 was biased at or below cut-off. With no amplifier, no output was available.

ANSWER SHEET
FOR
PROGRESS CHECKS
LESSON IV

Oscillator Operation

QUESTION NO.	CORRECT ANSWER
1	b
2	d
3	b
4	a
5	a
6	d
7	c
8a	VTVM
8b	Oscilloscope
8c	Standard VOM will load the circuit